REMARKS

Favorable reconsideration and allowance of the present patent application are respectfully requested in view of the following remarks. Claims 1-33 were pending prior to the Office Action. No claims are added or cancelled by this Reply. Therefore, claims 1-33 remain pending. Claims 1, 18, and **23** are independent.

Allowable Subject Matter

Applicants gratefully acknowledge the indication that claim 33 contains allowable subject matter.

Claim Objection

Claim 18 is objected as not providing sufficient antecedent basis for the elements recited therein. Claim 18 is amended herein to address the issue noted in the Office Action. Accordingly, withdrawal of the objection to claim 18 is respectfully requested.

Rejection under 35 U.S.C. §103(a) based on Lulli, Duffy, and Hecht

Claims 1, 3, 5-9, and 10-32 are rejected under 35 U.S.C. §103(a) as being unpatentable over Lulli et al. (U.S. Patent No. 5,870,196, hereinafter "Lulli") in view Duffy (U.S. Patent No. 3,767,308) and Hecht et al. (1979, hereinafter "Hecht"). Applicants respectfully traverse.

For a rejection under 35 U.S.C. §103(a) to be valid, a *prima facie* case of obviousness must be established. *See M.P.E.P. 2142.* One requirement for establishing a *prima facie* case of obviousness is that the cited references, when combined, must teach or suggest all claim limitations. *See M.P.E.P. 2142; M.P.E.P. 706.02(j).* Thus, if the cited art fails to teach or suggest one or more elements, the rejection is improper and must be withdrawn.

A key advantage of the present invention is that it provides for highly reliable measurement resolution using a lesser quality interferometer similar to that obtained using a high-quality interferometer by including a step of digital moiré subtraction of non-speckle interference fringe patterns. As a result, it is possible to construct interferometers having a very large aperture, a feature which the Examiner has previously identified as being patentable.

As has been discussed in previous filings and as detailed below, Lulli, Duffy, and Hecht, taken alone or in combination, fail to teach or suggest a step of digital moiré subtraction of non-speckled interference fringe patterns to obtain, using a conventional interferometer having a significant level of distortion/aberration, extremely reliable measurement resolution.

It is asserted in the Office Action that Lulli discloses a measurement method comprising the steps of (a) arranging a Michelson

interferometer (FIG. 1) to form a first interference fringe pattern comprising at least 50 interference fringes; (b) recording a digital image (Mx) of the first interference fringe pattern using a CCD camera (59); (c) perturbing (47, 57) an optical path in the interferometer by translating a reflecting surface (43) to form a second interference fringe pattern comprising at least ten interference fringes; (d) storing and processing the images using a central processing unit (14); and (e) combining a digital image (Mx+1) of the second interference fringe pattern with the recorded image of the first interference fringe pattern to produce a further image comprising a fringe pattern arising from a difference or differences between the first and second interference fringe patterns (Md=[Mx-Mx+1]), wherein negative values are converted to positive values.

Applicants respectfully disagree with the foregoing characterization of Lulli.

Concerning step (a), Lulli does not teach or suggest using an interferometer to form non-speckle interference fringe patterns. To the contrary, Lulli discloses using an interferometer to form SPECKLE images comprising no fringe patterns. In addition, Lulli clearly shows that interference fringe patterns (*see FIG. 2a*) and SPECKLE images (*see FIG. 2b*) require markedly different approaches with regard to their analysis. For example:

- At column 1, lines 27-31, Lulli states that traditional interferometry techniques, such as techniques developed for non-speckle interference fringe patterns, are useless for analyzing SPECKLE images on a rough surface.

- At column 3, line 48, through column 4, line 12, Lulli explains why transitional interferometry techniques are useless for analyzing SPECKLE images.

In view of the foregoing, it can readily be seen why the SPECKLE images obtained by Lulli are not equivalent to the non-speckle interference fringe patterns obtained according to the present invention. In fact, Lulli explicitly teaches away from any extrapolation between the analysis of SPECKLE images, on the one hand, and the analysis of non-speckle interference fringe pattern in classic interferometry, on the other hand.

With respect to step (b), Lulli does not teach or suggest recording a digital image of a first interference fringe pattern. Rather, Lulli merely discloses a digital SPECKLE image formed by interference of partially coherent light reflected by a first portion of a rough surface.

Regarding step (c), Lulli does not teach or suggest perturbing an optical path to form a second interference fringe pattern having a different number of interference fringes. Lulli only shows moving reference mirror 43 along axis 30 in one incremental step of a

predetermined quality δ to obtain a second SPECKLE image formed by interference of partially coherent light reflected by interference of partially coherent light reflected by the first portion of a rough surface. *See column 4, lines 39-43.* Therefore, while Lulli suggests modifying the optical path in the interferometer in a predetermined manner, Lulli does not teach or suggest perturbing an optical path in the interferometer.

Concerning step (e), Lulli does not teach or suggest producing a further image comprising a fringe pattern arising from a difference or differences between first and second images. Indeed, the binary image generated by Lulli on the basis of the difference matrix Md is unlikely to show a fringe pattern arising from a difference between first and second SPECKLE images.

It must be appreciated that Lulli does not teach or suggest combining two successive interference images in order to compensate for distortion/aberration in the interferometer. Indeed, Lulli's measurement technique is based on a specific, limited technical concept. That is, when partially coherent light is introduced in an interferometer to be reflected on a rough surface, interference is only achieved when the optical path lengths are equal. This is the basic principle underlying Optical Coherence Tomography (OCT). Lulli uses this OCT principle for profilometry. Lulli shows continuously stepping the mirror 43 in the reference arm of the

predetermined quality δ, and stopping at each step to determine which positions on the object surface satisfy the path-matching condition. In the algorithm of Lulli, this path-matching search is determined by simply subtracting and rectifying two frames acquired from two sequential steps.

Indeed, if at a certain location on the object surface (corresponding to a certain pixel on the CCD camera), no path-matching (i.e., no interference) occurs, there will be no difference between the intensities recorded for the same pixel in the two frames acquired before and after the step of the reference mirror. If, however, path-matching in the interferometer is achieved at a location on the surface at a particular step of the reference mirror, the intensity recorded by the same pixel is likely to fluctuate from one frame to the other.

In short, the sole aim of Lulli's subtraction step is to easily detect interference points (i.e., path matching) in SPECKLED interference patterns. On the other hand, in the present invention, non-speckled interference fringe patterns are obtained. In such non-speckled fringe patterns, there is interference at every image point, regardless of whether path-matching is achieved. It, therefore, follows that the subtraction step disclosed by Lulli for detecting path matching is completely useless for non-speckled interference fringe patterns.

Accordingly, one of ordinary skill in the art would not be prompted to modify the image processing algorithm of Lulli to include any kind of image subtraction into a measurement method using an interferometer-producing, non-speckled interference fringe pattern.

It is asserted in the Office Action that Duffy discloses that a moiré fringe pattern is obtained by superimposing two successive interference fringe patterns, and that the moiré fringe pattern indicates a change (displacement) in successive interference fringe patterns. It is concluded in the Office Action that it would have been obvious to one of ordinary skill in the art at the time the present invention was made to combine two successive interference fringe patterns to form a moiré fringe pattern, since the skilled artisan would be motivated to study the change in a sample as a function of depth.

Applicants respectfully disagree with this characterization. The apparatus of Duffy produces speckle images, and Duffy shows the use of a mask with two parallel slits to form interference gratings in the speckles of the speckle image. Obviously, such grated speckle images cannot be equated with a non-speckle interference fringe pattern.

Duffy discloses obtaining grated speckle images before and after displacement of a reflective rough surface and then optically

superimposing the images with the gratings in individual overlapping speckles. According to Duffy, the optically superimposed grated speckle images produce moiré bands that are representative of displacement of the surface. However, Duffy is silent as to how moiré patterns could be successfully used to improve measurements in classic interferometer techniques producing non-speckled interference fringe patterns.

To the contrary, the method and apparatus of Duffy constitutes a clear alternative for making interferometer measurements. *See column 11, lines 10-14.* Accordingly, one of ordinary skill in the art surely would not look to Duffy's method and apparatus for guidance in improving classic interferometer measurements.

Accordingly, conceived as an alternative to classic interferometer measurements, Duffy's processing of SPECKLE images provides no motivation to include the presently claimed step of digital moiré subtraction in interferometer measurement.

As shown, if neither Lulli nor Duffy may be relied upon to teach or suggest the above-recited feature, it then follows that the combination of Lulli and Duffy may not be relied upon to teach or suggest at least the same above-recited feature.

Moreover, Hecht has not been, and indeed cannot be, relied upon to cure the deficiencies of Lulli and Duffy.

It has been shown that the combination of the three cited references is improper. Therefore, for at least the above-stated reasons, claims 1, 3, 5-9, and 10-32 are distinguishable over the combination of Lulli, Duffy, and Hecht.

Applicant respectfully requests withdrawal of the rejection of claims 1, 3, 5-9, and 10-32 under 35 U.S.C. §103(a) based on Lulli, Duffy, and Hecht.

Rejection under 35 U.S.C. §103(a) based on Lulli, Duffy, and Noguchi

Claims 2 and 4 are rejected under 35 U.S.C. §103(a) as being unpatentable over Lulli in view of Duffy and further in view of Noguchi et al. (U.S. Patent No. 5,432,606, hereinafter "Noguchi"). Applicants respectfully traverse.

Claims 2 and 4 depend from independent claim 1. It has been shown that Lulli and Duffy do not teach or suggest the presently claimed invention as set forth in independent claim 1 and that claim 1 is distinguishable over Lulli and Duffy. Noguchi has not been relied upon to correct the deficiencies of Lulli and Duffy. Therefore, claims 2 and 4 are also allowable based on their dependence on independent claim 1, as well as for the additional limitations provided by these claims.

Applicant respectfully requests withdrawal of the rejection of claims 2 and 4 under 35 U.S.C. §103(a) based on Lulli, Duffy, and Noguchi.

CONCLUSION

All objections and rejections raised in the Office Action having been addressed, it is respectfully submitted that the present application is in condition for allowance, and such allowance is earnestly solicited. However, should there be any outstanding matters that may be resolved by a telephone conference, the Examiner is invited to contact Hyung Sohn (Reg. No. 44,346) at 703-205-8000 in an effort to expedite prosecution.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fees required under 37 C.F.R. §§1.16 or 1.17, particularly extension of time fees.

Respectfully submitted,
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